



SafeCoach - Frontal krockssäkerhet hos landsvägsbussar



Project within Vehicle and Traffic Safety

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FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi



1. Executive summary

Despite the fact that the bus & coach travel is one of the safest means of surface public transport, available European accident statistics show that frontal collisions involving buses and coaches are relatively high. Although a number of standards exist for the car and heavy truck sectors to reduce the car and bus occupant injury severity of frontal accidents, the bus and coach sectors have not come to an agreement on an unified categorization and harmonized standard of bus & coach frontal crashworthiness.

The objectives with this FFI VINNOVA granted project, *SafeCoach*, were to (1) develop internal evaluation methods and relevant criteria for the two most important sub-parts of coach frontal crashworthiness; driver/guide protection and car-to-coach compatibility, and to (2) develop new weight effective conceptual solution for future coach front structures.

Evaluation methods to assess the passive safety for coaches in frontal impacts have been developed based on both accident statistics for coaches and trucks and in-depths accidental data for coaches.

Requirements for the FUP (frontal underrun protection) have been investigated by studying car-to-barrier crash tests and car-to-truck crash tests. This has resulted in a 'desired' force-displacement curve for the FUP behaviour in car-to-coach impacts that assess energy absorption and underrun. The findings are applicable for both coaches and trucks.

Concepts that improve the frontal safety have been developed based on the evaluation methods. In total, thirteen studies on different concepts and variants have been made. The concepts have been developed with different objectives; some concepts merely improve the self-protection while others improve the car-to-coach compatibility or both. Furthermore, an underlying principal behind the concepts is that ideas from different concepts can be used in combination.

2. Background

Despite the fact that the bus & coach travel is one of the safest means of surface public transport, available European accident statistics show that frontal collisions involving buses and coaches are relatively high. Although a number of standards exist for the car and heavy truck sectors to reduce the car and bus occupant injury severity of frontal accidents, the bus and coach sectors have not come to an agreement on an unified categorization and harmonized standard of bus & coach frontal crashworthiness.



Available accident statistics and this lack of harmonised standards emphasises the need of further development of evaluation methods and new vehicle front structure concepts.

3. Objective

The objectives with this FFI VINNOVA granted project, *SafeCoach*, were to (1) develop internal evaluation methods and relevant criteria for the two most important sub-parts of coach frontal crashworthiness; driver/guide protection and car-to-coach compatibility, and to (2) develop new weight effective conceptual solution for future coach front structures. The work will be expected to lead to definition of future EU project proposals and, on the long run, to new standards.

4. Project realization

The project started in 2009 and was finished in 2011.

5. Results and deliverables

5.1 Delivery to FFI-goals

The objectives of the FFI - Vehicle and Traffic Safety programme are to contribute to the development of Zero Vision vehicles, i.e. vehicles with an optimum combination of active and passive systems to reduce the number of accidents and the consequences of those accidents which nevertheless occur. The project, *SafeCoach*, has contributed to the Zero Vision within the passive safety area and included both self-protection and compatibility. Self-protection is the safety for the occupants in the coach while compatibility is the safety of the occupants in the car in car-to-coach impacts.

Current crash test methods that assess frontal safety for coaches (and buses) are limited and needs to be further developed. Therefore, accident statistics was studied in order to develop evaluation methods that assess the safety coach in frontal impacts. Statistics that included severe and fatal injuries in accidents involving coaches were studied. The study included general both accident statistics as well as in-depth accidental data. The results were used to develop relevant crash tests for coaches that can distinguish 'safe' coach concepts from 'less safe' concepts.

Crash tests with cars were studied in order to further understand the very complex behaviour in car-to-coach impacts. Several car-to-barrier crash tests and car-to-truck crash tests were analysed. The results were used to develop requirements for the frontal underrun protection (FUP). The findings are applicable for both coaches and trucks.



The developed crash tests and the developed requirements for the underrun protection were used to first study the behaviour of current coaches and were then used to develop future coach concepts. The developed concepts will be used in future development of coaches.

The project, SafeCoach, has contributed to the FFI objectives by a detailed knowledge in self-protection for coaches and car-to-coach compatibility. Future Volvo coaches will be designed with consideration to the experiences obtained in the project. Furthermore, the knowledge will in the long run be used to develop new safety standards for coaches.

6. Conclusions and future research

Evaluation methods to assess the passive safety for coaches in frontal impacts have been developed based on both accident statistics and in-depths accidental data for coaches.

Requirements for the FUP (frontal underrun protection) have been investigated by studying car to barrier crash tests and car to truck crash tests. The findings are applicable for both coaches and trucks.

Concepts that improve the frontal safety have been developed based on the evaluation methods. In total, thirteen studies on different concepts and variants have been made. The concepts have been developed with different objectives; some concepts merely improve the self-protection while others improve the car to coach compatibility or both. Furthermore, an underlying principle behind the concepts is that ideas from different concepts can be used in combination.

7. Participating parties and contact person

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